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PROBLEMS IN THE REFORESTATION OF WATERSHEDS[1]

By George R. Taylor[2]

The American Waterworks Association is meeting here in Penn's Woods, that boundless domain, whose inexhaustible forests should have produced timber sufficient for countless generations. For years Pennsylvania led all states in the production of lumber. Even in 1900 we were producing enough timber to build houses for our people. Today we have passed from a living to a dead state. We are producing only enough lumber to make coffins to bury our people. Worse than that, we are cutting our remaining supplies much faster than we are growing them. In another decade we will have to depend on outside sources for even our coffins.

This same story may be told of practically every state east of the Rockies and north of the Mason and Dixon's Line. Even the South has reached the point where she can begin to count her remaining years of timber production. But it is unnecessary to go further into the question of our timber supplies. We are all agreed that a serious situation faces us and that the problem of reforesting our wild lands must be solved. The question is: "Who is to do it and how is it to be done."

Unquestionably the national and state governments should lead the way both in the experimental and the practical side of reforestation, Mr. Gifford Pinchot, our former State Commissioner of Forestry, tells us that there are 5,000,000 acres in what he has aptly termed "The Great Pennsylvania Desert." This area, he believes, should be owned by the State and developed into a system of state forests. Similar deserts exist in most of our eastern states and should be under state control. Yet with our state forestry departments working at full capacity, there would still remain much to be done. Little can be expected of the private owner, because few are willing to spend time, money and labor in a cause whose benefits are to be reaped by second and third generations. Only corporations having a continuity of existence sufficient to cover the sixty to one hundred years necessary to grow virgin timber, may be reasonably expected to make any real effort toward reforestation. Among such corporations there is none to whom forestry work should make a stronger appeal than our waterworks organizations, either privately or municipally controlled. There are numerous reasons why waterworks plants are particularly favorably situated for reforestation. They are frequently large owners of land which naturally has but few uses. They are interested in the run-off from the catchment area, the peaks of flood and the depths of drouth, the turbidity of the streams and the sanitary quality of the water; all of which would be more or less favorably influenced were the watershed largely covered with forests. It is clear that waterworks plants are vitally interested in reforestation. The problem then remains of how to get it done.

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Safety is the prime necessity in forest work and its synonym is fire protection. We have 5,000,000 acres in our Great Pennsylvania Desert because of forest fire, that curse of the forest which has turned our former woodlands into barren, desolate tracts. The first step in combating the forest fire evil in an efficient state forest fire system, with district fire wardens covering the entire state. Each district should have its fire towers and watchmen. The district warden should have authority and money to secure men to fight forest fires. Such a state-wide system is needed, if forest fire damage is to be reduced to a minimum. To supplement state effort, there should be effective work by the individual owner. In Pennsylvania, the State Department began a thorough state-wide fight against forest fires in 1920. This year, in the Scranton district, we have a district warden and 150 fire wardens to cover the 2264 miles.

Our own experience in fire protection covers twenty years of work, during 18 years of which we were absolutely alone in our efforts, receiving no help from either state or private owners. This fact must be borne in mind, as it has had much to do with the thoroughness of our preparations and the costs of our fire fighting service. We hold 19,000 acres of land scattered over three counties in Northeastern Pennsylvania. About 7000 acres are in a solid tract, 6 miles long and 2 wide, adjoining the City of Scranton and in part within the City limits. This area is readily accessible from the City by various public roads and the 16 miles of our own macadam road which we maintain upon it. It is, in fact, a great public park through which thousands of people pass on holidays and Sundays. Because of these conditions fires are numerous and we are forced to maintain a constant vigilant watch. In the center of the tract we have a large farm, where some 20 men are variously employed by us in farm work, road maintenance, sawmill and forest work, general watershed care and work on the city system. A watchman is kept on our fire tower and the men are always ready to drop their tools and rush to a reported fire. On Sundays and holidays they are kept in waiting, reenforced by an automobile truck to carry them rapidly over the territory. The district is roughly bisected by a road running through the entire tract and is further cut up by our own road system. It is divided into smaller blocks by our fire and land lines, which total about 20 miles in length. The care of these fire lines, watching for fires, and fire fighting have meant an annual expenditure of about 60 cents per acre for the entire tract. This is very high, but it has been made necessary because of the extreme fire hazard which we have to face. With all this care, 400 acres, or 6 per cent of the entire tract, have been burned over in the past ten years. In contrast to this we have 3000 acres on the head of our main stream, in a thinly settled region, where our only expense is to fight an occasional fire which starts from the railroad. Or again, a tract of about 1000 acres in a thickly settled farming district where fires are practically unknown and nothing is spent on fire protection. We feel that the activity of the State Forestry Department, in the near future, will materially lessen these high costs, as well as furnish more thorough protection.

In actual fire fighting men are equipped with four gallon galvanized iron canteens for carrying water which are strapped to their backs, chemical extinguishers, iron rakes, pails and so forth. Our main reliance is placed on beating the fire out by the use of water and evergreen boughs. It should be understood that we refer to surface fires in the low brush growing on our mountains, not of big timber fires. We fall back on our fire lines for back firing as a last resort, in case of high wind or rapid progress of the fire. The maintenance of fire lines is a problem in itself. Probably a fire line should be looked upon merely as a line from which to back fire. From this standpoint it might be a line 2 feet wide from which all top soil has been removed to make the line absolutely devoid of vegetation. On the other hand, a 20-foot line is more satisfactory in many ways. If a fire line is to be regarded as a line on which to hold a fire, a 20-foot line is more successful than the narrower one. In such a line the removal of the timber is follwed by a growth of sprouts, weeds, and brush which is more dangerous than the original stand. Mowing and burning every fall will keep the fire line in fairly good shape, but is attended with some hazard and encourages the growth of weeds. One method of removing this second growth is by grubbing the line with pick axes, removing the smaller sprouts by the roots and burning the line. This is expensive, as grubbing will cost from 30 to 40 cents a square yard. Furthermore, it is not complete and repeated grubbings are necessary before the line becomes a barren waste.

We have experimented with chemicals in killing the vegetation on our fire lines. Most chemicals, however, as they are washed out of the soil by rain, seem to stimulate the growth of weeds. We have used gas tar on our fire lines with a considerable degree of success. Gas tar, a residue from our gas works, is a thin sticky fluid, pours readily, is noninflammable at ordinary forest fire temperatures, is not readily washed out of the soil by rains and is very toxic to vegetation. We have applied this by hand, using sprinkling pots. It requires 1 to 2 gallons per square yard of fire line to be effective in killing vegetation. Just how long the tar will last we cannot say, but our lines after two or three summers are holding in good shape. We have not as yet put gas tar on a line where the only preparation had been to cut and burn the trees and brush. The quantity of tar would have to be increased, but we have no doubt that the results would be equally good, as the tar will kill sprouts of a year's growth. Gas tar is a by-product in water gas manufacture and may be sold for 5 cents per gallon. This is of tar of not more than 3 per cent water content. The tar as we have generally used it contains up to 25 per cent water which aids in pouring it, but decreases its toxic effect. We figure that it costs us from 10 to 15 cents per square yard to apply gas tar so as to form an effective fire line.

Where coniferous timber is removed there is left in the top layers of soil sufficient seed to insure natural regeneration of the forest. With hard wood the same results is effected by sprouts from the roots. The first fire on this tract destroys the seed and sprouts, successive fires burn out the top soil, until finally we have the barren tracts so common in our Pennsylvania mountains where only fire cherry, birch and poplar grow. In such lands artificial regeneration is an absolute necessity. Further than that, if one wishes to control the type of tree growth, it can only be done by planting. Then natural regeneration on lands which have been scarred by fire, even if very slightly, is extremely slow. The species of trees which should be planted are, first of all, those which are native to your particular section. In addition, experimental planting should be made of various other trees which may seem desirable. Planting should not be confined to a single species any more than you should put all your eggs into one basket. Consideration should be given also to future utilization of the timber. A water system can make more use of the soft woods than of the hard. With us the prevailing types of trees are the hard woods, such as maple, oak, beech and birch, so there has been no necessity to plant them. In selecting a species for a given tract, consideration must be given to the nature of the ground, swampy or dry, sheltered or exposed, whether open or covered with undergrowth, type of soil, and various other factors.

The following table will give the habitats of the principal soft woods of the eastern section.

SPECIES	SOIL	SHADE
White pine, P. Strobus	Moist to moderately dry	Very tolerant
Pitch pine, P. Rigida	Drier soils	Will stand some shade
Red pine, P. Resinosa	Moist to dry soil	Will stand some shade
Norway spruce, Picea Abies	Moist to swampy soil	Intolerant of shade
European larch, Larixdecidua	Gravelly soils	Intolerant of shade
Scotch pine, P. Sylvestris	Anything except swamp	Intolerant of shade
Austrian pine, P. Laricio	Dry to moist soils	Intolerant of shade

If you are fortunate enough to have old fields available for planting you may put in almost any species you wish and get satisfactory results. If you are planting old fire burns covered with sweet fern, briers, tangles of scrub oak and groves of poplar, fire cherry and gray birch with an occasional oak or maple thrusting its green crown up above the tangle to belie its fire-scarred trunk, you are practically limited to white pine on the drier tracts and either white pine or Norway spruce in the wetter locations. We have been trying pitch pine, P. Rigida, in places of moderate shade, but we have not had enough years of experience to determine how satisfactory it is going to be. White pine and Norway spruce are shade loving and will eventually find their way up through scrub oak and other low growing bushes. The trees obtained for planting are seedlings from one to three years old and 4 to 10 inches in height. They may be bought from private nurseries, as our earlier plantings were. Of recent years the Pennsylvania Department of Forestry has furnished forest trees free to planters, making a charge to cover the cost of digging, packing and transportation. A number of other state forestry departments are doing the same thing and it is an activity which waterworks people should urge in all states. Pennsylvania this year is sending out 4,000,000 seedlings, next year they expect 6,000,000, and in 1924 and thereafter they expect to have 20,000,000. The trees are bunched in fifties, boxed and shipped by express. Immediately upon receipt they should be inspected and "heeled in" in the ground. "To heel in," a furrow about 4 inches deep should be plowed in good soil which is reasonably free from stone. The bunches should be put in this furrow and the dirt packed back about the roots covering the stems in part. The row should not be more than two bunches wide to avoid heating. If the ground is partially shaded so much the better. "Heeled in" in this way trees may be kept in perfect safety for two weeks, during March and April.

We plant the trees from four to six feet apart, generally about four feet. The latter distance means 2700 trees to the acre, while six feet provides 1200 trees per acre. We make the holes with broad-bladed picks, known as mattocks. Following the pick men come the droppers carrying the trees in pails having a little water in them to keep the trees moist. One man will drop for two to three rows of pick men. Behind these come the men who actually plant the trees, one man to each row. The planting is very simple. Just stick the tree in the hole and scrape the dirt back in with the hand, a scraper or as some or our men seem to prefer, a small stone. This stone is then used to pack the dirt around the tree by striking the ground with it. Another way to firm the tree in is to step on the dirt that has been thrown back into the hole. This firming in process is very essential in tree planting. The imperative precaution to be taken in handling is the same as that for transplanting all trees—do not let the roots dry out. Bunches must not be left around to be exposed to the sun or air. The work should be so handled that those covering the trees keep well up with those dropping them. To mark the planting line the outside line of holes should be left unplanted on each trip across the piece of land being planted. If the planting site is at a distance from the place where they are heeled in, enough trees for the day's work should be brought up and heeled in at a convenient spot.

In old mowing land, where the land is smooth, it may be advantageous to plow shallow furrows to facilitate planting, although we have always preferred hand planting. Where the ground is favorable a force of men will put in 1200 to 1500 trees per man a day. In wild land covered with scrub oak and briers, the average may drop to 500 trees a day. The total cost of the trees in the ground, including the department charges for digging, expressage, and our labor for planting, will run from three to five dollars per 1000 trees.

Trees should be planted as early in the spring as the ground is workable. Trees planted in March and early April do very much better than those set in May, as the earlier trees get rooted before the hot weather of July scorches them. Many failures are traceable to late planting and even where they survive they remain in a stunted condition for some years before making a start. After planting little need be done for the trees, except to keep out fires. In later years, questions arise of thinning and utilization of the smaller trees in the tract which are being overgrown. These question have not come up with us as yet. One method of planting which has been tried in some instances is to plant the alternate rows to evergreens suitable for Christmas trees. In a few years these could be removed and sold, thus giving an early income from the area. The feasibility of this is debatable and we have never practised it. The mixed planting of trees has certain advantages over planting in pure stands. One important thing is that it tends to cut down damage due to disease.

We began our planting in 1912, putting out 80,000 white pine. We continued planting pine at intervals until 1918, when we began experimental plantings of different species. We have now put in 985,000 trees, of which 513,000 are white pine. We have tried Scotch pine, red pine, pitch pine, European larch, Norway spruce, white ash and black walnut. Our results have been somewhat varied in character. Some have been unqualified successes, others are as yet uncertain. By far the greater part of our trees have lived, although in some instances the growth has been very slow. Scotch pine has not grown very rapidly with us, contrary to general experience. Our pitch pine plantings have been too recent to form any definite idea, but, as it is a local tree, there is no reason why it should not succeed, if the particular site is favorable. European larch has been a complete failure with us, both in growth and in withstanding our severe winters. One planting has only 5 per cent of the trees living; another under different soil and exposure conditions has 40 per cent living; while a third is somewhat between the two. Norway spruce has given us 90 per cent living, but the seedlings do not grow. Some that were set out in 1918 have not grown more than 6 inches in that time. White ash was a complete failure as was also the planting of black walnut nuts. Red pine has been a great success so far. Practically 100 per cent of the trees have lived and the growth has been very satisfactory. We find, however, that they are very intolerant of shade. In one field there is a large patch of sweet fern covering nearly an acre. The red pine will not come up through this, either dying or standing still without making any growth. We plan to use red pine and pitch pine in the near future wherever possible. Yet, because of scrub growth already existing, probably 90 per cent of our land either must be planted to white pine or allowed to go through the slow and frequently unsatisfactory process of natural regeneration. Pitch pine and red pine are moderately resistant to fire, owing to the large amount of pitch in the bark. Pitch pine, in particular, will live through surface fires which kill all other trees.

The problems of tree diseases are becoming more and more pressing every year. We are only too familiar with the ravages of the chestnut blight and the resultant wiping out of the chestnut tree. The various scales attack some of our forest trees causing considerable damage. White ash is particularly affected by it and in our own section ash sprouts are being killed by scale to an alarming degree, if you consider the relative scarcity of these trees and their high value for lumber. White pine is attacked by the weevil, occasionally to such an extent as practically to destroy a plantation. The weevil is a white grub which bores the path of the leader, killing it. The tree is thus forced to make one of the lateral branches into a leader, in this way producing a crook. Usually the infection is not heavy enough to cause any more serious damage than this. The ravages of the gypsy and brown tail moths in New England are well known. All of those except the weevil were imported. The most serious importation of all is the white pine blister rust, which was brought into New England on imported white pine seedling, some twenty years ago. The disease has spread slowly over the north, until it is pretty well distributed over the white pine territory and threatens to wipe out the white pine tree as the chestnut blight has the chestnut.

White pine blister rust is an infection of the inner bark of young branches of white pines, which slowly travels down the trunk and eventually kills the tree. The life cycle of the rust is in three stages, the first two stages of which are passed on white pine, while the third stage is passed on members of the ribes family, i.e., currant and gooseberries, either wild or cultivated. Its first stage on the pine is the dormant stage, which lasts from two to four years before passing into the second or active stage. In this stage the bark is killed in the center of the infection, while toward the outer portion of the infection spores are produced. At the extreme edge mycelium threads extend the disease farther down the limb into the trunk bark. When the infection reaches the trunk the killing of the whole tree takes place rather slowly. The spores produced in the active stage on the pine can only grow on leaves of members of the ribes family, i.e., currants and gooseberries. In this third stage on ribes, spores are produced which will develop only on members of the five needled group of pines, the principal of which is white pine. Here it begins its life history over again. It is evident, therefore, that this rust will develop and spread only in those sections where both white pine and ribes are present. It is desirable, therefore, to growth either one of the two in a given district, but not both. An infected white pine does not directly infect the white pine which stands beside it, but the spores must pass from the diseased tree to some currant bush. New spores must be formed and these pass back to the sound pine tree. The spores which are formed on the pine tree are of high vitality and may be transmitted over long distances by the wind, animals, birds, moving vehicles and other agencies. The spores which are formed on the ribes plant are frail and of low vitality so they are carried only relatively short distances. We find, therefore, rather unexpectedly, perhaps, that currants and gooseberries are becoming infected over wide areas which were supposed to be free from the disease, but that the infection of the white pines is taking place more slowly and over more limited areas. One to six hundred yards may be set as the limiting distances over which infection of the pines from diseased ribes may take place, with 200 yards representing the maximum, except under extremely favorable conditions. It will be seen that we are not facing whosesale slaughter of the pines, as was the case with the chestnut tree. The fact that the disease does not spread from tree to tree makes its progress slower and furthermore makes the possibility of its control much more certain. Control of the white pine blister seems possible through extermination of all gooseberries and currants which are within two hundred yards of a given stand of white pines. At first thought this may seem prohibitive in cost, but work, which has been done in New England and New York would indicate that on many tracts the costs are very reasonable. We have not as yet done any work on removing ribes. We expect to send out inspection parties this summer to determine how numerous ribes are and to get some idea of the cost of digging them out. One may naturally ask why plant white pine at all under these conditions. · There are several reasons why we should continue to plant white pine, if there is any possible chance of success. First, there is no tree which produces timber of the quality of white pine. Second, white pine will thrive under a greater variety of condition as to soil and moisture than most other trees. Third, no other soft wood, except spruce, can be planted in thick growths such as birch, poplar and scrub oak, with any assistance of the plantation growing up through the scrub. In our opinion there is no tree possessing the merits of white pine for general forest planting and we are loath to give it up without a struggle. As to substitutes, there are none. Red pine seems the most satisfactory one to try. It is hardy, a rapid grower, makes good lumber, is not subject to any known disease but has the fatal defect, for us at any rate, that it cannot be depended upon to come up through growth of underbrush. Its use must be restricted to fairly open ground. In this respect it is similar to Scotch and Austrian pine and the larches. The spruces will endure shade but are not very satisfactory for planting in the drier soils.

Tree diseases have made more complicated the problems of natural regeneration, as well as those of planting. They have brought up also the question of the utilization of the dead and dying trees in the already existing stands.

We are operating a small portable sawmill, utilizing first of all the dead chestnut and other timber and, in addition, taking out mature specimens of all trees for which we have use. We saw our own rough construction material, together with such specialties as pipe blocks, stone boat, ties, wagon poles, fence posts and a variety of plank and timber. Much of this utilization work has been a direct result of the ravages of the chestnut tree blight. A considerable quantity has been sold as mine props, either on the stump or at the mine. Our own cuttings have been carried out in as careful a manner as possible. All brush has been burned and, in many cases, the small chestnut sprouts have been removed to lessen the fire hazard and improve the general condition of the woods. We are sawing about

75,000 board feet of lumber every winter and 10,000 to 15,000 pipe blocks. Fire wood, except high grade fire place wood, has no value in the anthracite region, so everything below log size must be burned. The cost of operation is necessarily high, as we are picking the cut out of the general forest growth. However, we have been able to produce lumber at approximately local cost price when engaged on straight lumbering work. We feel further that we have done a valuable work by removing dead and dying timber which was rapidly becoming a serious fire menace. Another factor to be considered here is the constant employment furnished the men. This is of great value in lessening seasonal unemployment.

We believe that the reforestation of our watersheds has sufficient merit to be adopted by every member of the American Waterworks Association. Further, the Association should help this work by urging upon our various state forestry departments the adoption of broad and liberal policies, looking toward the reforestation of all our waste lands. The Association should stand behind all agencies which are endeavoring to restrict the spread of tree diseases by quarantine and inspection of shipments and, if necessary, by the enforced removal of plants which may act as hosts. It is worthy of note that the gypsy moth, the chestnut blight, the white pine blister rust, and other tree diseases were imported prior to the federal law prohibiting the importation of trees and shrubs except under special authorization. Had this law been in force twenty-five years ago we might have been spared at least some of the enemies listed.

In summary, it should be stated that fire protection is the Alpha and Omega of reforestation. Without it all attempts are useless. Those varieties should be planted which are native to your section and which will furnish the lumber you desire. Experiment with such other varieties as give promise of success. Keep a constant watch for tree diseases. Cooperate in every way with the various state and national agencies who are endeavoring to combat, by quarantines and various wars of extermination, the microscopic enemies of forest life. Utilize the existing timber which you already have.

Finally, regard reforestation as a necessary waterworks policy, not merely because of its possible economic value, but on the broader grounds of sanitary control, greater stability of run-off and conservation of the timber resources of the nation. We should feel it a duty to recreate "Penn's Woods" that our children's children may derive their water supplies, in part at least, from the fair green forests of our forefathers.